Mitral Clip: Who Is It for? How Is It Guided?

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Disclosures

Speakers Bureau (Abbott, Boston Scientific, Medtronic, Philips)
Advisory Board (Siemens)
Mitral Interventions

A

MitraClip

Pascal: MitraClip Alternative

B

Transcatheter Mitral Valve Replacement (TMVR)

C

Prosthetic Paravalvular Leak (PVL) Closure

D

Valve-in-Valve

Valve-in-Ring

Valve-in-MAC
Mitral Interventions

**A**

- **MitraClip (Abbott)**
  - FDA Approved for Degenerative & Functional MR

- **Pascal (Edwards)**
  - Clinical Trials
  - In Progress

- **Mitrail Transcatheter Edge-to-Edge Repair (TEER)**
Approval in the United States

MitraClip is approved for both degenerative AND functional mitral regurgitation repair

<table>
<thead>
<tr>
<th>Degenerative MR</th>
<th>Functional MR</th>
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<tbody>
<tr>
<td>MitraClip approved by FDA in <strong>2013</strong></td>
<td>MitraClip approved by FDA in <strong>2019</strong></td>
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</tbody>
</table>
Degenerative vs. Functional Mitral Regurgitation
Degenerative vs. Functional Mitral Regurgitation

Degenerative Mitral Regurgitation
Sick valve >>> sick ventricle

Functional Mitral Regurgitation
Sick ventricle >> sick valve

1. LEAFLETS
2. MITRAL ANNULUS
3. CHORDAE TENDINEAE
4. PAPILLARY MUSCLES (posteromedial + anterolateral)
5. LEFT VENTRICULAR MYOCARDIUM

Degenerative Mitral Regurgitation
Mitral valve prolapse: role of 3D echocardiography in diagnosis

Ricardo Benenstein and Muhamed Saric

Purpose of review
To review the utility and the latest developments in three-dimensional (3D) echocardiography of mitral valve prolapse.

Recent findings
Although 3D echocardiography was invented in 1974, it did not gain wide clinical acceptance until the introduction of real-time 3D echocardiography in the first decade of the 21st century. Driven by improvements in probe technology and increases in computing power, 3D echocardiography now provides unprecedented images of mitral valve prolapse and its associated mitral regurgitation with no or minimal requirements for image post-processing.

Summary
3D echocardiography has become the echocardiographic modality of choice for establishing the diagnosis, describing the precise anatomy, and visualization of mitral regurgitant jets in mitral valve prolapse. 3D echocardiography is becoming indispensable in guiding surgical and percutaneous methods of mitral valve repair and replacement.

Keywords
mitral valve prolapse, real-time 3D echocardiography, transesophageal echocardiography, transcoracic echocardiography

INTRODUCTION
The word prolapse (from Latin ‘to slip forward’) has been used since the 17th century to refer to slipping of a body part (such as the uterus) from its usual position. It appears that the term prolapse was first applied to the mitral valve in 1966 by Criley et al. [1].
Degenerative MR – Prolapsed / Flail Segment

82-year-old woman
Sudden onset of exertional dyspnea

Cobra Sign
P2 over A2
Degenerative MR – Prolapsed / Flail Segment

82-year-old woman
Sudden onset of exertional dyspnea
Degenerative MR – Prolapsed / Flail Segment

82-year-old woman
Sudden onset of exertional dyspnea

Henri Coandă
(1886-1972)
Romanian Aeronautics Engineer
3D TEE: Flail P2

'Snail Sign'
3D TEE: Flail P2

'Snail Sign'
3D TEE: Flail P2
Functional Mitral Regurgitation
Carpentier Classification of Native Mitral Regurgitation

Alain Frédéric Carpentier (b. 1933 in Toulouse) French surgeon

Based on mitral leaflet mobility

<table>
<thead>
<tr>
<th>Type I</th>
<th>Normal Leaflet Mobility</th>
</tr>
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<tbody>
<tr>
<td>• Annular dilatation</td>
<td></td>
</tr>
<tr>
<td>• Leaflet perforation</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Type II</th>
<th>Increased Leaflet Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mitral valve prolapse</td>
<td></td>
</tr>
<tr>
<td>• Ruptured chordae</td>
<td></td>
</tr>
<tr>
<td>• Ruptured papillary muscle</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type III</th>
<th>Decreased Leaflet Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>• IIIA - Rheumatic</td>
<td></td>
</tr>
<tr>
<td>• IIIB – Papillary muscle displacement (as in ischemic heart disease)</td>
<td></td>
</tr>
</tbody>
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Degenarative MR

Functional MR


The French Correction is a word play on The French Connection, a 1971 movie about smuggling heroin from Marseille to New York.
50-y/o man with nonischemic dilated cardiomyopathy due to ethanol abuse
Functional MR – Annular Dilatation

50-y/o man with nonischemic dilated cardiomyopathy due to ethanol abuse
Functional MR – Ischemic Etiology

66-y/o man with ischemic cardiomyopathy (prior RCA infarct)
Functional MR – Ischemic Etiology

66-y/o man with ischemic cardiomyopathy (prior RCA infarct)
Functional Ischemic MR: Crooked Smile

LA Side

LV Side
Functional Ischemic MR: Crooked Smile
2020 ACC-AHA Indications for TEER
# 2020 ACC/AHA: TEER Recommendation

<table>
<thead>
<tr>
<th>MR Severity</th>
<th>Severe</th>
<th>Severe</th>
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<tbody>
<tr>
<td>Symptoms</td>
<td>Symptomatic</td>
<td>Persistent symptoms while on optimal GDMT</td>
</tr>
<tr>
<td>Mitral Valve Anatomy</td>
<td>Appropriate anatomy as defined on TEE</td>
<td>Appropriate anatomy as defined on TEE</td>
</tr>
<tr>
<td>Additional Requirements</td>
<td>• Prohibitive surgical risk</td>
<td>• LVEF between 20% and 50%</td>
</tr>
<tr>
<td></td>
<td>• Life expectancy &gt; 1 year</td>
<td>• LVESD ≤ 70 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PASP ≤ 70 mmHg</td>
</tr>
<tr>
<td>Level of Recommendation</td>
<td>2A</td>
<td>2A</td>
</tr>
</tbody>
</table>
1° (Degenerative) Mitral Regurgitation
2° (Functional) Mitral Regurgitation

Secondary Mitral Regurgitation

- GDMT supervised by an HF specialist (1)

Severe MR Stage D
(RVol ≥60 mL, RF ≥50%,
ERO ≤0.40 cm²)

Undergoing CABG

LVEF ≥50%

- Severe persistent symptoms on optimal GDMT and AF Rx

LVEF <50%

- Persistent symptoms on optimal GDMT

- Mitral anatomy favorable
  - LVEF 20%–50%
  - LVESD ≤70 mm
  - PASP ≤70 mm Hg

NO
- Severe symptoms

MV surgery (2b)

Transcatheter edge-to-edge MV repair (2a)

MV surgery (2b)

MV surgery* (2a)
MitraClip: Technology
Percutaneous vs. Surgical Intervention

Percutaneous interventions typically emulate and try to **replicate an existing surgical technique**
Percutaneous vs. Surgical Intervention

**Mitral clip** procedure is a percutaneous emulation of the surgical **edge-to-edge repair (Alfieri stitch)**
Alfieri Edge-to-Edge Stitch Repair

First conceived in 1991

Ottavio Alfieri
b. 1947
Italian Cardiac Surgeon

Pledged Sutures at the Site of Mitral Regurgitation (Typically A2/P2)
Alfieri Edge-to-Edge Stitch Repair

**June 1991**: Alfieri scheduled 2 OR cases on the same day:

- **Case #1**: ASD Repair
- **Case #2**: Mitral valve repair of Barlow’s disease

While repairing the ASD, he noted that patient #1 also had something else....

...*congenital* double-orifice mitral valve without significant regurgitation.

He then reasoned that creating an *artificial* dual-orifice mitral valve might eliminate mitral regurgitation in patient #2.
History of Mitral Prolapse & Repair

1973
John Brereton Barlow
South African cardiologist (1924-2008)
Describes the concept of ‘billowing’ of the posterior mitral leaflet

1974
John Michael Criley
American cardiologist (b. 1931)
Coins the term ‘mitral valve prolapse’ while at Hopkins (now at UCLA)

1974
Alain Frédéric Carpentier
French surgeon (b. 1933)
Develops the surgical ‘French correction’

1999-2003
Ottavio Alfieri
Italian surgeon (b. 1947)
Developed the concept of mitral valve clipping

1991
Frederick St Goar
American cardiologist (b. 1957)
Surgical edge-to-edge repair first performed

2013
Mitral valve clip approved by FDA in the US
Group portrait with Frederick St Gor
TCT Meeting, Washington, DC
October 29, 2016
Alfieri Stitch vs. Mitral Clip
Alfieri Stitch vs. Mitral Clip | LV Side

Alfieri Stitch

Mitral Clip
Alfieri Stitch vs. Mitral Clip | LA Side

2 Alfieri Stitches

2 Mitral Clips
Mitral Valve Clipping

Percutaneous, transvenous, transseptal procedure for treatment of mitral regurgitation that emulates surgical edge-to-edge repair (Alfieri stitch).

MitraClip®
4-mm wide cobalt chromium V-shaped clip covered with polyester cloth

Original Owner
Evalve, Inc.
Menlo Park, CA
(1999-2009)

Current Owner
Abbott Vascular
Abbott Park, IL
(since 2009)
Mitral Valve Clipping

Percutaneous, transvenous, transseptal procedure for treatment of mitral regurgitation that emulates surgical edge-to-edge repair (Alfieri stitch).

3rd Generations MitraClip
Mitral Valve Clipping

Percutaneous, transvenous, transseptal procedure for treatment of mitral regurgitation that emulates surgical edge-to-edge repair (Alfieri stitch).

<table>
<thead>
<tr>
<th>G4 Clips: Width &amp; Height</th>
<th>NT</th>
<th>XT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>4/15</td>
<td>4/18</td>
</tr>
<tr>
<td>Wide</td>
<td>6/15</td>
<td>6/18</td>
</tr>
</tbody>
</table>

Additional G4 System Features:
- New guide sheath for live hemodynamics
- Independent grippers
- Simplified clip deployment

4th Generations MitraClip
Clip Guidance

1° Degenerative Mitral Regurgitation

2° Functional Mitral Regurgitation
Clip TEE Guidance: Degenerative MR
Pre-Clip Echo Evaluation

4 Questions to Answer

Q1: Mitral regurgitation type
   - Is mitral regurgitation degenerative or functional?

Q2: Severity of mitral regurgitation
   - Is mitral regurgitation at least moderate to severe (3+ or 4+)?

Q3: Mitral valve anatomy
   - Is mitral valve anatomy suitable for clipping?

Q4: Contraindication
   - Are there any general procedural contraindication for this left atrial procedure?
MitraClip® Summary

ECHONOMY
Tools for Echocardiographic Calculations
Muhamed Saric, MD, PhD
New York University

Mitral Clip Screening

Exclusion Criteria

Below are the basic anatomic exclusion criteria for mitral valve clipping in addition to the following:

- A2 or P2 calcification in the grasping area or the presence of any significant cleft
- Primary regurgitant jet NOT originating from malcoaptation of the A2 and P2
- Severe mitral annular calcifications
- Mitral stenosis (mitral valve area < 4.0 cm²)
- LV end-systolic diameter > 5.5 cm
- LVEF ≤ 25%
- Presence of ASD (whether repaired or not) or significant atrial septal aneurysm
- Presence of LA thrombus, vegetation or mass
- Presence of PFO associated with clinical symptoms

Source: saric.us/echonomy
Case Presentation

74-year-old man
- Severe degenerative mitral regurgitation due to flail P2
- Recently he noted marked dyspnea on exertion
- Frail, multiple comorbidities
- Referred for percutaneous mitral clip procedure
Case Presentation

74-year-old man
- **Severe degenerative mitral regurgitation** due to flail P2
- Recently he noted marked **dyspnea** on exertion
- Frail, multiple comorbidities
- Referred for percutaneous mitral clip procedure
Degenerative MR – Myxomatous Degeneration

74-year-old man
Recent onset of exertional dyspnea
Degenerative MR – Myxomatous Degeneration

74-year-old man
Recent onset of exertional dyspnea
Question

Should this patient undergo mitral clip procedure?
Because the patient has **severe symptomatic mitral regurgitation** AND is **high surgical risk**...

...he should be evaluated for **mitral clip** as he has high surgical risk.
MitraClip® Procedure Overview

1. Femoral venous access
2. Trans-septal puncture
3. Mitral Clip Deployment
MitraClip® Procedure: Septal Crossing of Guide Catheter
MitraClip® Procedure: Introduction of Clip Delivery System
MitraClip® Procedure: Positioning of Clip Delivery System
MitraClip® Procedure: Leaflet Grasping
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MitraClip® Procedure: Leaflet Grasping
MitraClip® Procedure: Grasping

Leaflet

Grippers

Leaflet

Clip Arm

Clip Arm
MitraClip® Procedure: Clip Deployment
MitraClip® Procedure: Deployment

Note the relative absence of chordae in the $A_2/P_2$ region.

This makes $A_2/P_2$ region the ideal place for mitral clipping.
MitraClip® Procedure: Clip Release
MitraClip® Procedure: Clip Endothelialization
MitraClip® Animation Sped Up
Transeptal Puncture
Transeptal Puncture for Mitral Clip

Right Atrial Side of Septum

- Appropriate Superior Height
- Posterior Stick
- << Foramen ovale
Transeptal Guidance by Biplane TEE
Transeptal Guidance by TEE
Clip Guidance: Delivery Sheath in LA
Clip Guidance: Clip Arms Open in LA
Clip Guidance: Clip Arms Open in LA
Clip Guidance: Grasping Leaflets in LV

COMMISSURAL VIEW

LVOT VIEW
Clip Guidance: Leaflets Grasped

Resolution of Mitral Regurgitation
Clip Guidance: Leaflets Grasped

No clip-induced mitral stenosis (mean gradient 3 mm Hg)
Clip Guidance: Clip Released
Clip Guidance: Clip Released

LA Side
Clip Guidance: Clip Released

LA Side: No Residual MR
Typically, ASD at the site of transseptal puncture is small and left alone.
Clip TEE Guidance: Functional MR
Case Presentation

59-year-old man with **ischemic cardiomyopathy** and **severe mitral regurgitation** admitted for yet another episode of congestive heart failure exacerbation despite optimal medical therapy at home

**Past Medical History**

- Myocardial infection at age 48 years
- Hypertension
- AIDS

**Past Surgical History**

- CABG at age 49 years
Coronary Angiography

- Extensive native CAD
- LIMA to LAD is the only patent graft
- No further percutaneous revascularization deemed feasible
TTE: Apical 3-Chamber View
TTE: Apical 2-Chamber View
TTE: Apical 2-Chamber View
TTE: Apical 4-Chamber View
EKG-gated Cardiac 3D-CT

LVEF 32%
TTE: Apical 4-Chamber View

Systolic (S) wave reversal in RUPV
TTE: Parasternal Long-Axis View

LV end-diastolic diameter 5.9 cm
TTE: Apical Views

LVEF by Biplane Simpson’s ~35%
TTE Conclusion

• Severe functional ischemic mitral regurgitation
• LVEF ~ 35%
• LV end-diastolic diameter 5.9 cm
What is His Risk of Surgical Repair?

Procedure: Isolated MVR

- Risk of Mortality: 4.983%
- Renal Failure: 4.540%
- Permanent Stroke: 1.628%
- Prolonged Ventilation: 20.893%
- DSW Infection: 0.663%
- Reoperation: 4.024%
- Morbidity or Mortality: 28.276%
Pre-Clip Echo Evaluation

4 Questions to Answer

- **Q1: Mitral regurgitation type**
  - Is mitral regurgitation degenerative or functional?

- **Q2: Severity of mitral regurgitation**
  - Is mitral regurgitation at least moderate to severe (3+ or 4+)?

- **Q3: Mitral valve anatomy**
  - Is mitral valve anatomy suitable for clipping?

- **Q4: Contraindication**
  - Are there any general procedural contraindication for this left heart procedure?
MitraClip: FDA Requirements
Functional MR: MitraClip Requirements

- Severe MR
- $20\% \leq \text{LVEF} \leq 50\%$
- LV end-systolic diameter $\leq 7.0$ cm
- Symptomatic despite optimal medical therapy
MitraClip: Anatomic Requirements
Preprocedural TEE

**MR JET ORIGIN**
- The primary regurgitant jet is non-commissural
- If a secondary jet exists, it must be considered clinically insignificant

**MV AREA**
- Mitral valve area ≥ 4.0 cm²

**GRASPING AREA**
- Minimal calcification
- No cleft in the grasping area
Preprocedural TEE

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Preprocedural TEE

**MR JET ORIGIN**
- The primary regurgitant jet is non-commissural
- If a secondary jet exists, it must be considered clinically insignificant

**MV AREA**
- Mitral valve area ≥ 4.0cm²

**GRASPING AREA**
- Minimal calcification
- No cleft in the grasping area
Contraindications for MitraClip

- Active endocarditis of the mitral valve
- Rheumatic mitral valve disease
- Evidence of intracardiac, inferior vena cava (IVC) or femoral venous thrombus
- Intolerance to procedural anticoagulation or post procedural antiplatelet regimen
Patient is a candidate for MitraClip procedure to treat severe symptomatic functional ischemic MR
Procedural TEE: 3 Mitral Clips
Procedural TEE: 3 Mitral Clips

LA Side

LV Side
Procedural Success: **MR Jet**

<table>
<thead>
<tr>
<th>Baseline</th>
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<tbody>
<tr>
<td><img src="image1" alt="Baseline Image" /></td>
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<table>
<thead>
<tr>
<th>Post 3 Clips</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2" alt="Post 3 Clips Image" /></td>
</tr>
</tbody>
</table>
Procedural Success: Pulmonary Vein

Baseline

Post 3 Clips

S wave ↑

S wave ↓
Procedural Success: Mitral Inflow

Baseline: E >> A

Post 3 Clips: E ~ A

Mean Gradient: 3 mm Hg at 80 bpm
Conclusion

Functional mitral regurgitation treated successfully with implantation of 3 mitral clips
Question #1

67-year-old patient with severe functional mitral regurgitation and persistent symptoms despite medical therapy. Which of the following LVEF values qualifies the patient for a mitral clip procedure?

A. < 20 %
B. 20 – 50%
C. 35 – 50%
D. > 50%
E. > 60%
Question #1

67-year-old patient with severe functional mitral regurgitation and persistent symptoms despite medical therapy. Which of the following LVEF values qualifies the patient for a mitral clip procedure?

A. < 20 %
B. **20 – 50%**
C. 35 – 50%
D. > 50%
E. > 60%
Question #2

Placement of a mitral clip is technically easiest in which of the following mitral valve locations?

A. A₁/P₁
B. A₂/P₂
C. A₃/P₃
D. Lateral commissure
E. Medial commissure
Question #2

Placement of a mitral clip is technically easiest in which of the following mitral valve locations?

A. $A_1/P_1$
B. $A_2/P_2$  
C. $A_3/P_3$
D. Lateral commissure
E. Medial commissure
Thank You

New York University Langone Health